Observation of the Early Stages and 3D-2D Transition of MOCVD Grown GaN with LT-GaN Buffer Layer

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Elucidation of the growth mechanism of group-III nitride thin films is very important to obtain device quality epitaxial layers. We have observed the early stages and the transition from three-dimensional (3D) islands growth to two-dimensional (2D) growth of MOCVD-GaN films on sapphire substrates. 2μm thick undoped-GaN films were grown at 1035°C in an ECORE D-125 multi-wafer rotating disc low-pressure MOCVD system equipped with *in-situ* photo-reflectance monitor. 30nm thick GaN layers grown at 510°C were used as buffer layers. Growth pressure for GaN layers was 200Torr. V/III ratio was varied from 1000 to 10000 by changing the flow of TMGa. Growth rate changed from 3.0μm/h to 0.63μm/h according to the change of V/III ratio.

Figure 1 shows the room temperature photoluminescence (PL) spectra of undoped-GaN films grown under the same growth conditions except for the V/III ratio. The higher the V/III ratio was, the stronger band-edge emission and the weaker deep-level emission were observed. Figure 2 shows the reflectance traces of the samples seen in Fig.1. A clear trend in roughening and recovery stages [1)] was observed in their reflectance characteristics. The higher the V/III ratio was, the longer roughening stage and the slower recovery occurred. On the contrary, when V/III ratio was as low as 1000, oscillations with small amplitude occurred rather early in the roughening stage and reflectance intensity recovered rapidly. It means that lateral growth is facilitated and coalescence stage is expedited without allowing much roughening[1)]. Figure 3 shows the surface morphologies of the buffer layer and the early growth stages of GaN at the stages indicated in Fig.2. The density of nuclei (islands) formed at the initial stage of the GaN growth was almost the same with that of the columnar structures[2)] of the buffer layer. The change in surface morphology during the early growth stage of GaN on LT-GaN was similar to that on LT-AlN[2)]. The surface morphology at roughening stage was found to change depend on the V/III ratio.

Finally we observed 3D-2D transition layers with a Lasertec 1LM21DW scanning laser microscope (LSM). Figure 4 shows the LSM images of the GaN films seen in Fig.1. The features observed here exhibit the transition layer from 3D to 2D growth mode, i.e. overall structure of the trapezoid crystals observed through two-dimensionally grown sound-zone layers[2)]. Very large scale structures of the order of several tens micron in diameter were observed. When V/III ratio was 1000, cloudy honeycomb structure and no grain structure were observed. When V/III ratio was between 1700 and 2500, spherical grain structures like dividing and multiplying cells were observed. Grain size of them was varied between around 10μm and 50μm in diameter, and it decreased slightly with increasing V/III ratio. When V/III ratio was 5000, polygonal structure was observed. When V/III ratio was 10000, no grain structure was observed showing the abrupt transition layer from 3D to 2D growth mode.

From the results obtained above, we summarize that larger V/III ratio brings longer roughening time and sharper 3D-2D transition resulting higher quality of GaN films.

1) T.-B.NG, J. Han, R. M. Biefeld and M. V. Weckwerth: J. Electron. Mater. **27** (1998), 190.
2) K. Hiramatsu, S. Itoh, H. Amano, I. Akasaki, N. Kuwano, T. Shiraishi and K. Oki: J. Cryst. Growth, **115** (1991), 628.

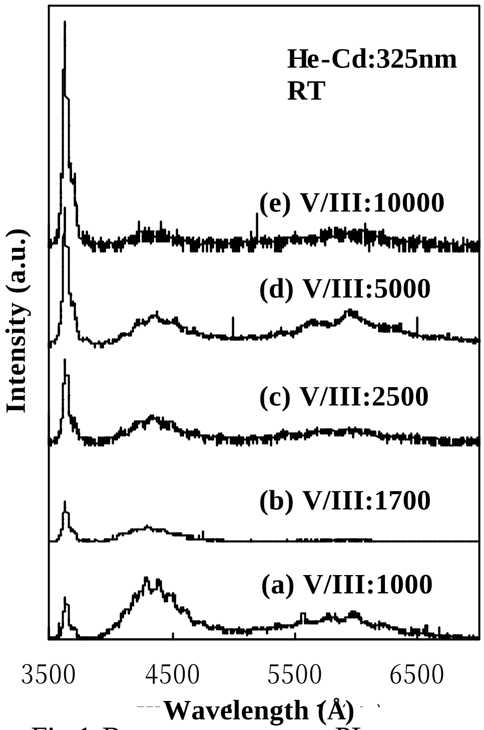


Fig.1 Room temperature PL spectra of undoped-GaN films grown under the same growth conditions except for V/III ratio.

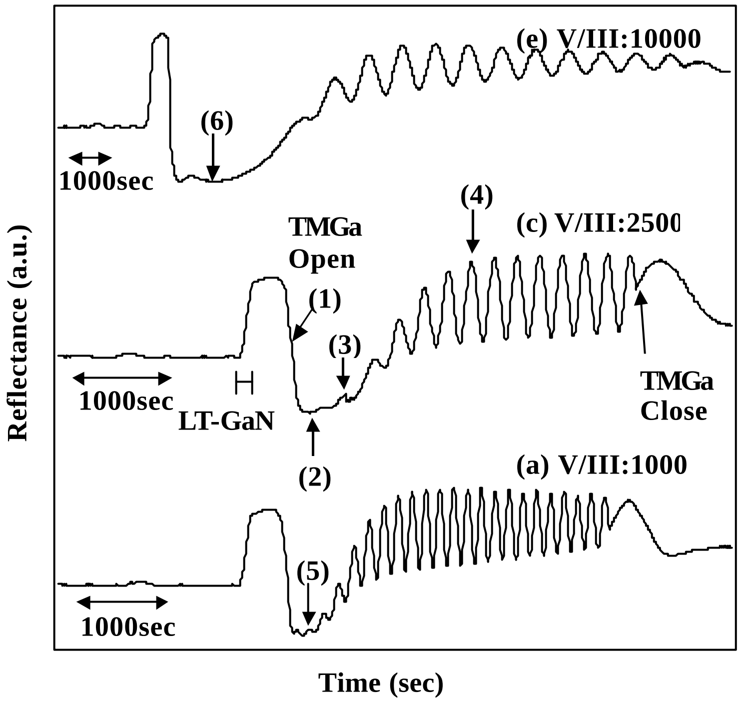
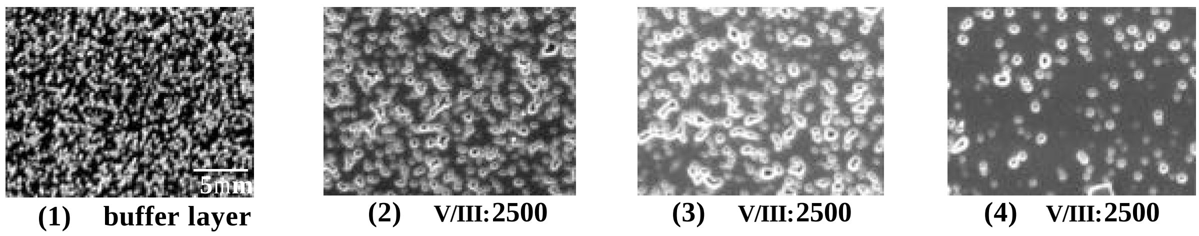


Fig.2 Reflectance traces from three GaN samples seen in Fi.1.



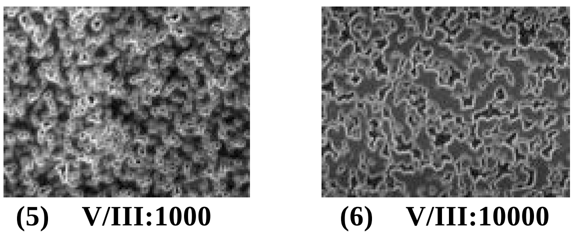


Fig.3 SEM images of the buffer layer and the early growth stages of GaN films at the points indicated in Fig.2.

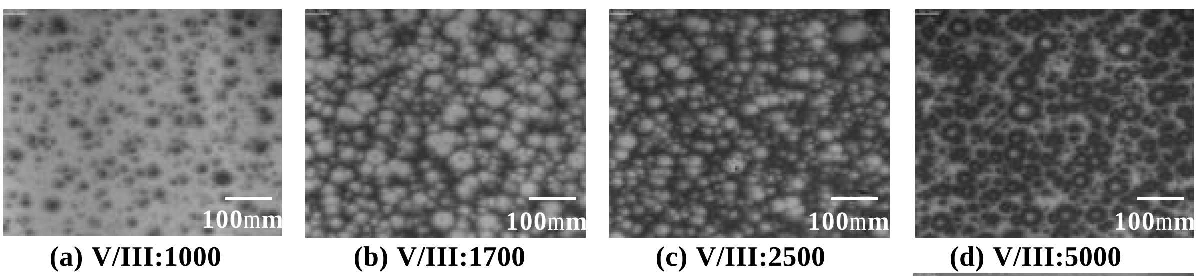


Fig.4 Scanning laser micrographs of the samples seen in Fig.1.